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World Distribution and Flow of Major Mineral Commodities

Bureau of Mines

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BIBLIOGRAPHIC DATA SHEET	1. Report No. BuMines PR 2-76	2.	PB 255 963

4. Title and Subtitle World Distribution and Flow of Major Mineral Commodities	5. Report Date 4-28-76
	6. Performing Organization Code
7. Author(s) Dr. John D. Morgan, Jr. Associate Director - US Bureau of Mines	8. Performing Organization Rept. No.
9. Performing Organization Name and Address US Bureau of Mines, Department of the Interior 2401 E Street, NW Rm. 1038 Washington, D.C. 20241	10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Agency Name and Address As above	13. Type of Report & Period Covered Presentation, 1976 14. Sponsoring Agency Code

15. Supplementary Notes Presented before Workshop "A" of NAE-NAS Symposium on Materials and the Development of Nations: The Role of Technology, Washington, D. C., April 28, 1976.

16. Abstracts

World mineral production is closely related to world steel production. World steel production for the past 25 years is graphed for five major areas: USA, Common Market, Japan, USSR, and the rest of the world. Detailed tables compare the following for major countries and land areas: area; population; iron ore and raw steel production, scrap and steel consumption; bauxite, alumina, and aluminum production, aluminum consumption; tin mine and smelter production, and consumption; copper mine, smelter, and refinery production and consumption; crude oil and petroleum refinery production and consumption; and coal production and consumption. The role of minerals, including scrap, in the U.S. economy is assessed in detail.

17. Key Words and Document Analysis. 17a. Descriptors

Minerals, mineral economics, steel, copper, aluminum, tin, petroleum, coal, scrap, imports, exports, transportation, U.S. Bureau of Mines

17b. Identifiers/Open-Ended Terms

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For Workshop "A" of NAE-NAS Symposium
on "Materials and the Development of
Nations: The Role of Technology",
Washington, D.C. April 28, 1976

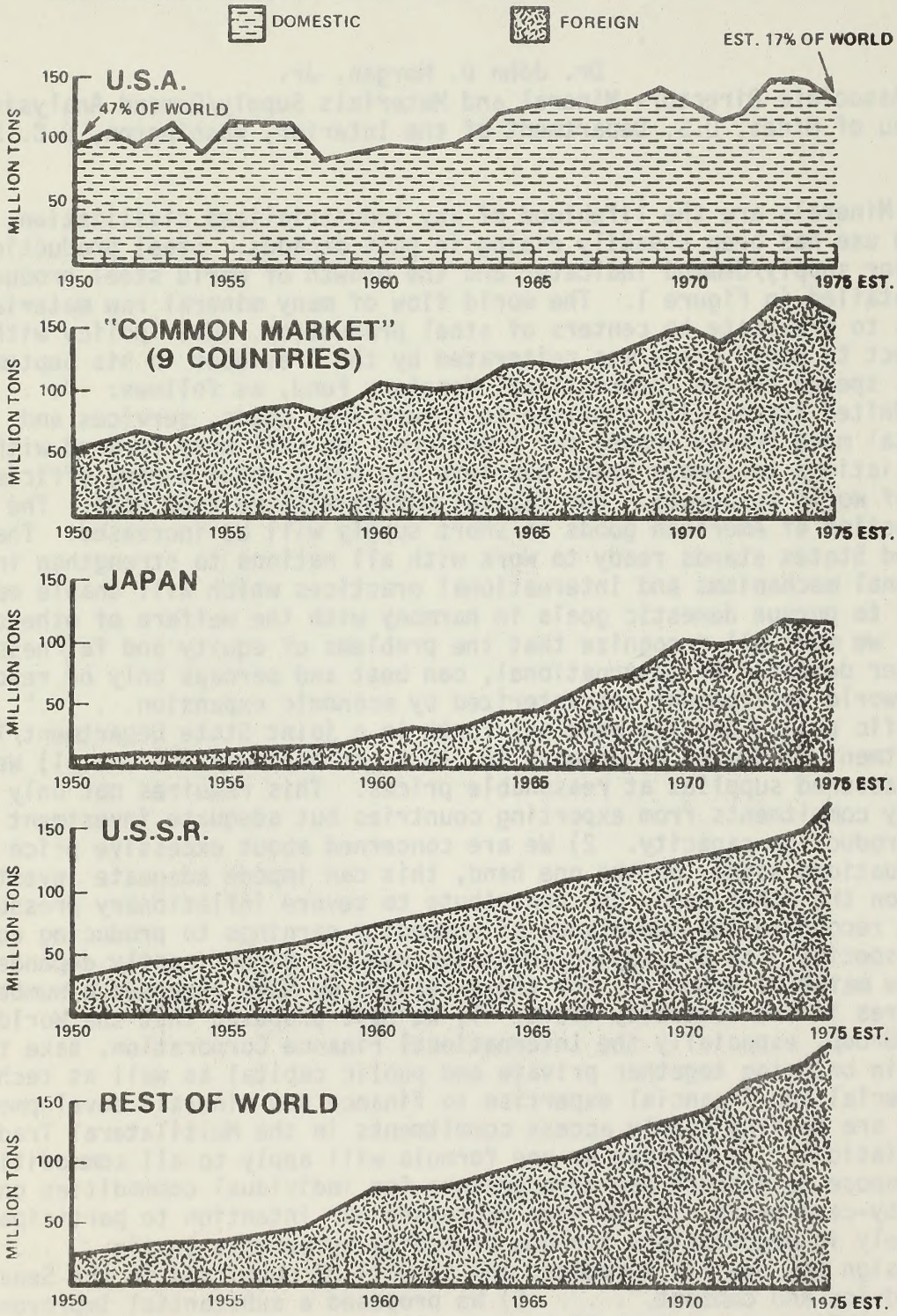
WORLD DISTRIBUTION AND FLOW OF MAJOR MINERAL COMMODITIES

Dr. John D. Morgan, Jr.
Associate Director--Mineral and Materials Supply/Demand Analysis
Bureau of Mines, U.S. Department of the Interior, Washington, D.C. 20241

Minerals are the lifeblood of any industrialized civilization, and world use has been steadily rising in past decades. Steel production is a major supply/demand indicator and the growth of world steel production is detailed in Figure 1. The world flow of many mineral raw materials tends to gravitate to centers of steel production. U.S. policy with respect to world trade was reiterated by the President in his September 2, 1975, speech to the International Monetary Fund, as follows: ". . . . The United States will continue to insure that goods, services and capital move freely across our frontiers. We will move forward with negotiations to remove trade barriers and bring about a more efficient use of world resources. Our capital market will be kept open. The production of American goods in short supply will be increased. The United States stands ready to work with all nations to strengthen international mechanisms and international practices which will enable each of us to pursue domestic goals in harmony with the welfare of others. . . . we must all recognize that the problems of equity and fairness, whether domestic or international, can best and perhaps only be resolved in a world environment characterized by economic expansion. . . ." More specific policy details were set forth in a joint State Department/Treasury Department statement on January 16, 1976, as follows: ". . . 1) We seek assured supplies at reasonable prices. This requires not only supply commitments from exporting countries but adequate investment in new production capacity. 2) We are concerned about excessive price fluctuations since, on the one hand, this can impede adequate investment and, on the other hand, can contribute to severe inflationary pressures. 3) We recognize the importance of commodity earnings to producing countries and especially to developing countries who are significantly dependent on raw material exports. For these reasons we have proposed a number of measures in the commodity field: 1) We have proposed that the World Bank Group, especially the International Finance Corporation, take the lead in bringing together private and public capital as well as technical, managerial and financial expertise to finance new minerals development. 2) We are seeking supply access commitments in the Multilateral Trade Negotiations. 3) Because no one formula will apply to all commodities, we propose to discuss new arrangements for individual commodities on a case-by-case basis. 4) We have expressed our intention to participate actively in negotiations for new commodity agreements in tin. . . . We will sign the new Tin Agreement and it will be submitted to the Senate for advice and consent. . . . 5) We proposed a substantial improvement in the IMF's compensatory finance facility. At the recent IMF meeting

Figure 1

WORLD STEEL PRODUCTION



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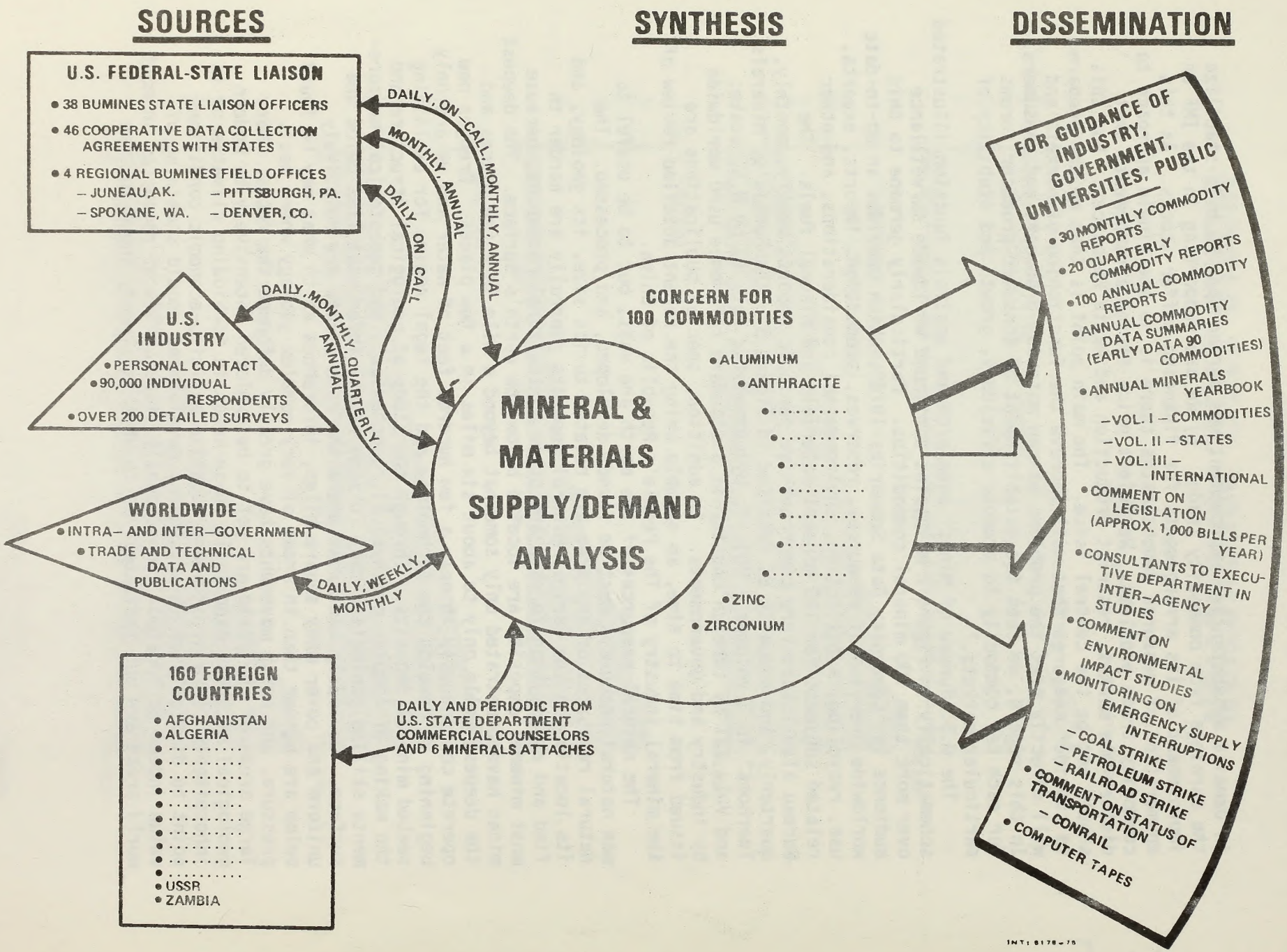
U. S. DEPARTMENT OF THE INTERIOR

in Jamaica a substantial improvement was agreed upon to help stabilize the earnings from commodity trade. 6) We are supporting in the IMF an improvement of its arrangements for financing buffer stocks. As this enumeration of measures demonstrates there is no one single approach to commodity trade problems. We reject price fixing arrangements that distort the market, restrict production and waste resources. But this should not be the central issue. The main point is that we are prepared to consider measures that will improve the functioning of markets and will directly meet the problems of raw material producers and consumers. In this regard, we seek the establishment of consumer-producer forums for each key commodity to promote efficiency, growth and stability of particular markets."

The U.S. Bureau of Mines' supply/demand analysis function illustrated schematically in Figure 2 maintains continued worldwide surveillance over more than 100 mineral commodities. Particularly germane to this audience is "Commodity Data Summaries-1976", which provides an up-to-date worldwide overview of resources, reserves, production, imports, exports, use, recycling, substitution, environmental considerations, and other related subjects for 100 mineral materials and mineral fuels. The Bureau also issues very comprehensive periodic reports weekly, monthly, quarterly, and annually as detailed in Figure 3. The Bureau's "Minerals Yearbook" in 3 volumes - Vol. I, by commodity; Vol. II by U.S. state; and Vol. III by foreign country is a standard reference used worldwide by industry and governments. In addition, special publications are issued from time to time, an example being the recent detailed review of the mineral industry of The People's Republic of China.

The natural resources of the earth are vast, but to be useful to man natural resources must be found, developed, and processed. The natural resources of any area are related to its size, its geology, and its location on the earth. Mineral deposits generally are harder to find and assess than forests and other agricultural resources, because most mineral deposits are located below the earth's surface. The deepest mines have penetrated only somewhat beyond a mile in a few places and the deepest wells only to about six miles in a few places. Dredges now operate continuously in only a few hundred feet of water and we are only beginning to develop the technology and the legal regime for exploiting seabed mineral deposits. Through the study of geological structure and the making of complex geophysical, geochemical, and geobotanical measurements skilled geologists can, in some cases, infer what lies below the surface. Obviously, in areas where the rock strata are relatively uniform and cover many square miles, inferences as to what may be found below are better than in areas of very complex geology where heat, pressure, and earth movements have greatly deformed the rocks. Many large areas of the world are yet to be explored intensively by modern geological methods, especially those areas in forbidding climates or in inhospitable terrain, or where negative politico-economic conditions point to difficulties in subsequent development should something of value indeed be located. Consequently, tabulations of resources in most world areas are but indicators as to what is already known to some

Figure 2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DISSEMINATION
U.S. FEDERAL-STATE LIAISON
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Figure 3

FREQUENCY OF REGULARLY ISSUED BUREAU OF MINES COMMODITY REPORTS

(W=WEEKLY, M=MONTHLY, Q=QUARTERLY, A=ANNUALLY)

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ASBESTOS (A)
BARITE (A)
BAUXITE (Q)
BERYLLIUM (A)
BISMUTH (Q,A)
BORON (A)
BROMINE (A)
CADMIUM (Q,A)
CALCIUM-MAGNESIUM CHLORIDE (A)
CARBON BLACK (Q,A,)
CEMENT (M,A)
CESIUM AND RUBIDIUM (A)
CHROMIUM (M,A)
CLAYS (A)
COAL, BITUMINOUS (W,A)
COAL, BITUMINOUS DISTRIBUTION (Q)
COAL, ANTHRACITE (W,A)
COAL, ANTHRACITE DISTRIBUTION (A)
COBALT (M,A)
COBALT REFINERS (Q)
COKE AND COAL CHEMICALS (M,A)
COKE DISTRIBUTION (A)
COKE PRODUCERS (A)
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COPPER INDUSTRY (M,A)
COPPER PRODUCTION (M)
COPPER SULFATE (Q)
DIATOMITE (A)
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FERROALLOYS (SEMIANNUAL)
FERROSILICON (Q,A)
FLUORSPAR (Q,A)
GEM STONES (A)
GOLD AND SILVER (M,A)
GRAPHITE (A)
GYPSUM (M,A)
IODINE (A)
IRON AND STEEL (A)
IRON AND STEEL SCRAP (M,A)
IRON ORE (M,A)
KYANITE AND RELATED MATERIALS (A)
LEAD INDUSTRY (M,A)
LEAD, PRIMARY PRODUCTION (M)
LIME (M,A)
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MAGNESIUM AND MAGNESIUM COMPOUNDS (A)
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MERCURY (Q,A)
MICA (A)
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MINOR NONMETALS (A)
MOLYBDENUM (M,A)
NATURAL GAS (M,A)
NATURAL GAS LIQUIDS (M)
NATURAL GAS PROCESSING PLANTS (BI-ANNUALLY)
NATURAL GAS PRODUCTION, WORLD (A)
NICKEL (M,A)
NITROGEN (A)
PEAT (A)
PEAT PRODUCERS (A)
PERLITE (A)
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- ASPHALT SALES (A)
- AVIATION TURBINE FUELS (A)
- BURNER FUEL OILS (A)
- CRUDE OIL PRODUCTION, WORLD (A)
- CRUDE OIL AND PRODUCTS PIPELINE MILEAGE (TRI-ANNUALLY)
- DIESEL FUEL OILS (A)
- DISTRICT V PETROLEUM STATEMENT (M,A)
- FUEL OIL AND KEROSINE SALES (A)
- FUEL OILS BY SULFUR CONTENT (M)
- MOTOR GASOLINES (SUMMER) (A)
- MOTOR GASOLINES (WINTER) (A)
- PETROLEUM REFINERIES IN U.S. (A)
- PETROLEUM STATEMENT, ADVANCE RELEASE (M)
- PETROLEUM STATEMENT (M,A)

PHOSPHATE ROCK (M,A)
PLATINUM GROUP METALS (Q,A)
POTASH (A)
PUMICE AND VOLCANIC CINDER (A)
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SALT (A)
SAND AND GRAVEL (A)
SELENIUM (Q)
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SODIUM COMPOUNDS (A)
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degree, and are by no means definitive as to total content. Nevertheless, a major contribution to world knowledge in this area is the recent Professional Paper 820 of the U.S. Geological Survey.

Mineral deposits that have been found, adequately drilled to determine their content of valuable minerals, and that can be mined, processed, and converted into useful materials with known technology at reasonable prices are commonly called "reserves." For example: the rocks of the earth's crust average about 5% iron; the United States has vast resources of rocks containing more than 5% iron; the iron ore reserves of the United States are 17,000,000,000 tons, which in turn contain 4,000,000,000 tons of recoverable iron metal, compared to U.S. raw steel production of 118,000,000 short tons in 1975.

Agricultural materials are generally renewable in relatively short time spans, in that some crops can be raised four or five times a year, annual cycles are common, and softwood trees can be raised on fifteen to twenty year cycles. Modern agriculture, however, is heavily dependent upon minerals for machinery, fuel, fertilisers, trace elements and pesticides. Mineral deposits normally are formed only over much longer periods of time--usually tens of millions or hundreds of millions of years. Consequently, the total supply of all minerals accessible to man in the earth's crust is, to all practical purposes, relatively fixed, and hence mineral materials are of major concern to nations with heavy industry.

Other than in nuclear processes, elements are neither created nor destroyed--man's processing merely combines them in certain ways, recombines them, or reduces combinations into elemental form. The materials industries are engaged in extracting elements from natural materials, and/or combining or recombing them into forms more useful to man. Nature itself is constantly engaged in vast processing activities, in which the "carbon-oxygen" and "nitrogen" and "hydrologic" cycles are major examples.

For most purposes there are great interchangeabilities in materials. For example: rubber can be made from: natural latex from rubber trees, carbon and hydrogen from alcohol from grain or other agricultural materials, carbon and hydrogen from hydrocarbons from petroleum, natural gas, coal, etc.; and buildings can be constructed from: steel, aluminum; copper, glass, stone, slate, concrete, tile, wood, plastics, plywood and many, many other materials. In the United States today the tonnage of plastics used annually exceeds the combined tonnages of aluminum, copper, lead, and zinc, and, on a volume basis, the use of plastics is approaching the volume of steel. Recycling, too, holds promise for both improving environments and stretching supplies. Metals have been recycled since before the dawn of history, and long ago the recycling of human and animal wastes in many nations reduced the need for chemical fertilisers and also recycled essential trace elements.

In specialized technological applications in which a multiplicity of properties are required, as for example: a combination of strength, electrical conductivity, temperature resistance, corrosion resistance, and creep resistance, available materials are much more limited. If

substantial breakthroughs in energy are to be achieved greatly improved temperature-resistant materials must be developed. Figure 4 shows that there are only a very limited number of elements which possess such properties.

Table 1 compares the size, population, and steel production of major world areas. Major minerals moving in world trade are covered as follows: Table 2, Iron and Steel, and Tin; Table 3, Aluminum and Copper; and Table 4, Petroleum and Coal. These tabulations show that Latin America, Asia, Australia-New Zealand, and Africa are major exporters of mineral raw materials, while Western Europe and Japan are major importers of mineral raw materials. Such broad generalizations, however, are insufficient to portray properly the flows of minerals, and for any particular nation it is necessary to consider value added by manufacturing, recycling, the balance of trade, and the degree of import dependence, as is illustrated in the case of the United States by Figures 5, 6, 7, and 8 respectively. More details on the United States and other nations will be found in the References.

Increased production and productivity in the mining, minerals, metal, mineral reclamation, and energy industries requires politico-economic climates that will encourage innovation, cooperation, and investment in new and improved technology and rapid introduction in all stages of the mineral cycle including:

Exploration
Mining and petroleum and natural gas production
Processing
Use
Recovery and Recycling

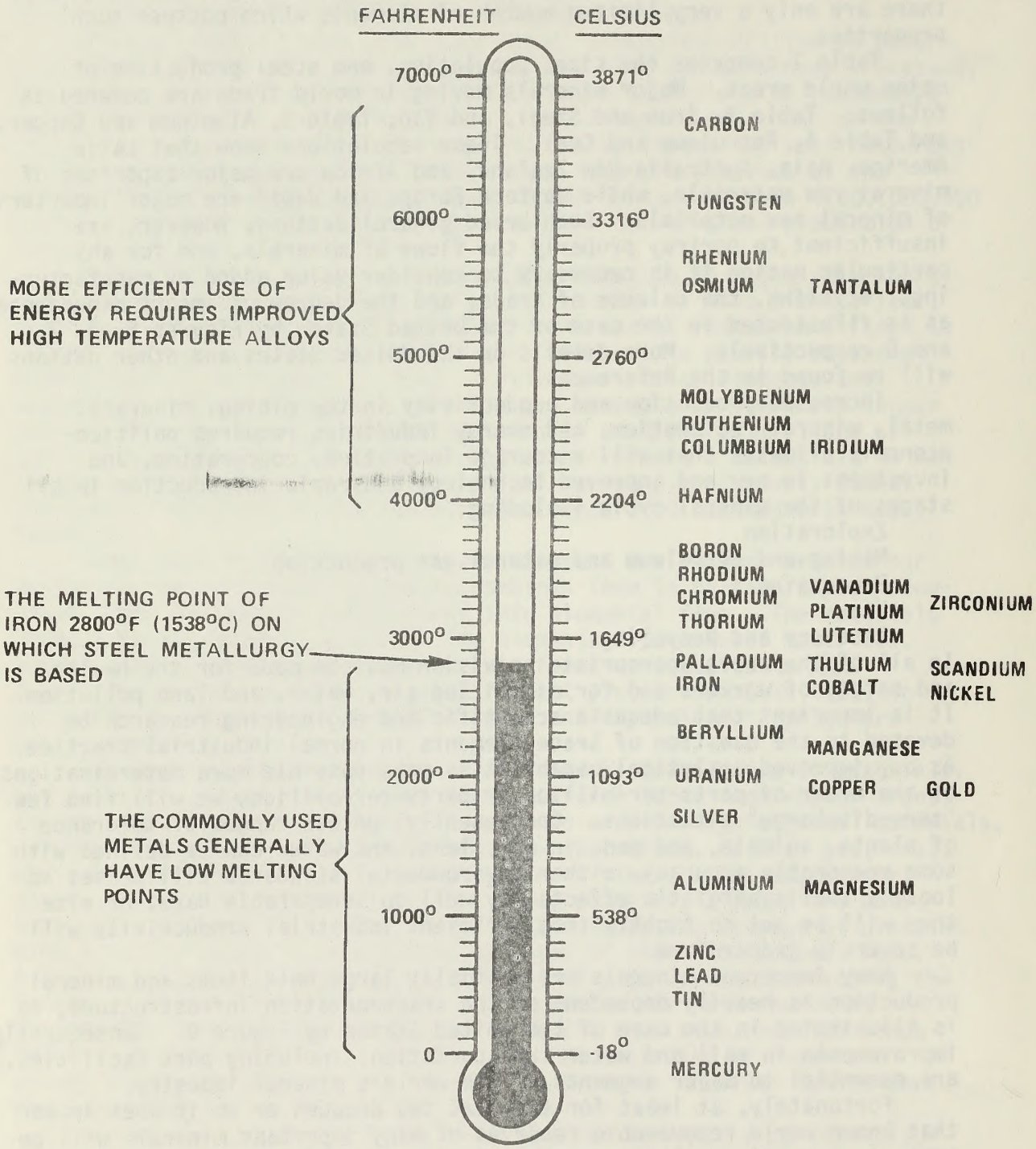
In all of the above appropriate provision must be made for the health and safety of workers and for minimizing air, water, and land pollution. It is important that adequate scientific and engineering research be devoted to the question of trace elements in normal industrial practice. As our improved analytical capabilities make possible more determinations of the order of parts-per-million or parts-per-billion, we will find few "zero-discharge" situations. Consequently, unless ranges of tolerance of plants, animals, and man, in air, land, and water can be defined with some reasonable accuracy, either environmental standards will be set so loosely that synergistic effects may well do irreparable harm, or else they will be set so tightly that efficient industrial productivity will be severely jeopardized.

Many important minerals are initially large bulk items and mineral production is heavily dependent on the transportation infrastructure, as is illustrated in the case of the United States by Figure 9. Consequently, improvements in rail and water transportation, including port facilities, are essential to major segments of the world's mineral industry.

Fortunately, at least for the next two decades or so it does appear that known world recoverable reserves of many important minerals will be adequate to meet cumulative needs. A further positive factor results from the large quantities of capital goods already accumulated in many advanced societies, which thus afford such advanced societies the ability to postpone some demands if actual or arbitrarily-caused mineral shortages

Figure 4

MELTING POINTS



(THIS CHART SHOWS ALL KNOWN ELEMENTS WITH MELTING POINTS ABOVE IRON AND MAJOR METALS MELTING AT LOWER TEMPERATURES)

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should develop. Consequently, as family planning becomes a reality in populous less-developed nations, there should be no foreseeable reason in periods of general peace why the peoples of the earth cannot look forward to continually improving material living standards.

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Table 1

Geography

	Area (million sq. kilometers)	1974 population (millions)	1974 steel production (million metric tons)
United States-------	9.3	210	130
Canada----------	10.1	22	15
Latin America-------	20.7	300	20
Western Europe------	3.9	370	185
Comecon----------	1.0	110	50
U.S.S.R.----------	22.3	250	135
China, P.R.---------	9.6	800	25
Japan----------	0.3	110	115
Other Asia----------	17.1	1,215	15
Australia, New Zealand----------	8.5	20	8
Africa----------	30.3	380	7
Total----------	133.1	3,787	705

Comparisons (U.S.= 1)

	Area	1974 population	1974 steel production
United States-------	1	1	1
Canada----------	1.1	.1	.1
Latin America-------	2.2	1.4	.2
Western Europe------	.5	1.8	1.4
Comecon----------	.1	.5	.4
U.S.S.R.----------	2.4	1.2	1
China, P.R.---------	1	3.8	.2
Japan----------	-	.5	.9
Other Asia----------	1.8	5.8	.1
Australia, New Zealand----------	.9	.1	.1
Africa----------	3.3	1.8	.1
Total----------	14.3	18.0	5.5

Table 2

Iron and steel, 1974
(Million metric tons)

	Production of iron in ore	Consumption of scrap	Production of raw steel	Consumption of raw steel equivalent
United States	50	75	130	170
Canada	30	7	15	15
Latin America	80	8	20	30
Western Europe	55	80	185	165
Comecon	3	25	50	50
U.S.S.R.	135	55	135	140
China, P.R.	30	6	25	30
Japan	-	40	115	75
Other Asia	30	4	15	15
Australia, New Zealand	65	2	8	9
Africa	40	3	7	6
Total	518	305	705	705

Tin, 1974
(Thousand metric tons)

	Mine production	Smelter production	Consumption
United States	0	6	50
Canada	-	0	6
Latin America	35	10	8
Western Europe	4	25	65
Comecon	1	1	15
U.S.S.R.	30	30	35
China, P.R.	20	20	15
Japan	1	1	35
Other Asia	115	120	9
Australia, New Zealand	10	7	5
Africa	15	8	3
Total	231	228	246

Table 3

Aluminum, 1974
(Million metric tons,
aluminum content)

	Production in bauxite	Production in alumina	Production of primary metal	Consumption of primary metal
United States	.5	3.5	4.5	4.5
Canada	0	.6	1.0	.4
Latin America	6.5	2.5	.3	.4
Western Europe	1.5	2.0	3.5	3.5
Comecon	.6	.6	.5	.7
U.S.S.R.	.8	1.5	1.5	1.5
China, P.R.	.2	.2	.2	.3
Japan	0	.9	1.0	1.5
Other Asia	.8	.2	.4	.4
Australia, New Zealand	4.5	2.5	.4	.2
Africa	1.5	.4	.3	.1
Total	16.9	14.9	13.6	13.5

Copper, 1974
(Million metric tons,
copper content)

	Mine production	Smelter production	Refinery production	Consumption
United States	1.5	1.5	1.5	2.0
Canada	.8	.5	.6	.3
Latin America	1.0	1.0	.7	.3
Western Europe	.2	.5	1.0	2.5
Comecon	.4	.5	.5	.5
U.S.S.R.	.7	.7	.7	1.1
China, P.R.	.1	.1	.1	.3
Japan	.1	1.0	1.0	.8
Other Asia	.4	.1	.1	.1
Australia, New Zealand	.4	.2	.2	.1
Africa	1.5	1.5	1.0	.1
Total	7.1	7.6	7.4	8.1

Table 4

Petroleum, 1974
(Million metric tons)

	Crude production	Refinery production	Consumption
United States	430	610	800
Canada	80	90	80
Latin America	250	300	180
Western Europe	20	710	690
Comecon	20	80	70
U.S.S.R.	460	390	350
China, P.R.	60	50	50
Japan	-	250	260
Middle East	1,100	130	80
Other Asia, ex Middle East	110	140	140
Australia, New Zealand	20	30	30
Africa	260	40	50
Total	2,810	2,820	2,780

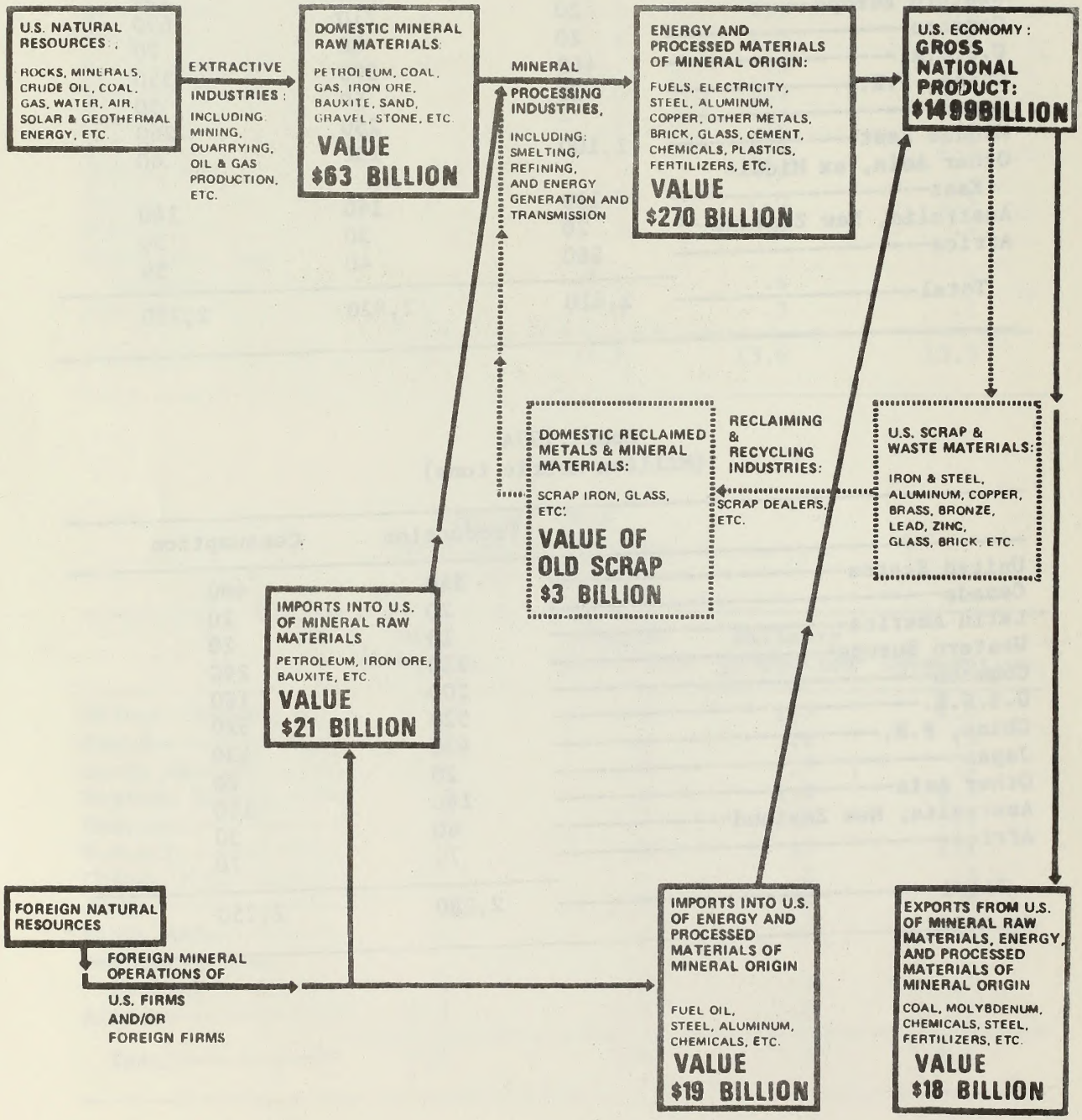
Coal, 1974
(Million metric tons)

	Production	Consumption
United States	540	480
Canada	20	20
Latin America	10	20
Western Europe	250	290
Comecon	200	160
U.S.S.R.	520	510
China, P.R.	430	430
Japan	20	80
Other Asia	160	160
Australia, New Zealand	60	30
Africa	70	70
Total	2,280	2,250

Figure 5

THE ROLE OF MINERALS IN THE U.S. ECONOMY

(ESTIMATED VALUES FOR 1975)

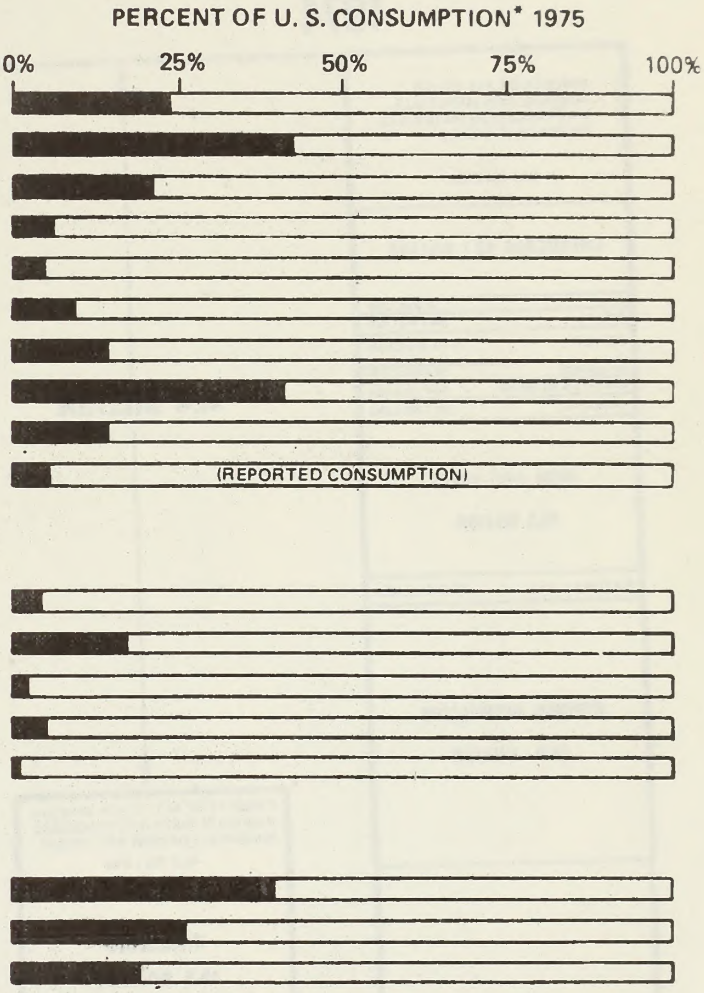


BUREAU OF MINES, U.S. DEPARTMENT OF THE INTERIOR (Based in part on U.S. Department of Commerce data)

Figure 6

OLD SCRAP RECLAIMED IN THE U.S. (1975)

MAJOR	SHORT TONS
IRON	25,300,000**
LEAD	497,000
COPPER	353,000
ALUMINUM	304,000
ZINC	49,000
CHROMIUM	38,000
NICKEL	35,000
ANTIMONY	16,600
TIN	8,400
MAGNESIUM	6,000
MINOR	
TUNGSTEN	375
MERCURY	319
COBALT	130
TANTALUM	25
SELENIUM	5
PRECIOUS	
SILVER	1,498
GOLD	31
PLATINUM GROUP	0



* APPARENT CONSUMPTION = U.S. PRIMARY + SECONDARY PRODUCTION + IMPORTS - EXPORTS ± GOV'T STOCKPILE AND INDUSTRY STOCK CHANGES.

** INCLUDES EXPORTS

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Figure 7

U.S. IMPORTS AND EXPORTS OF RAW AND PROCESSED MINERALS

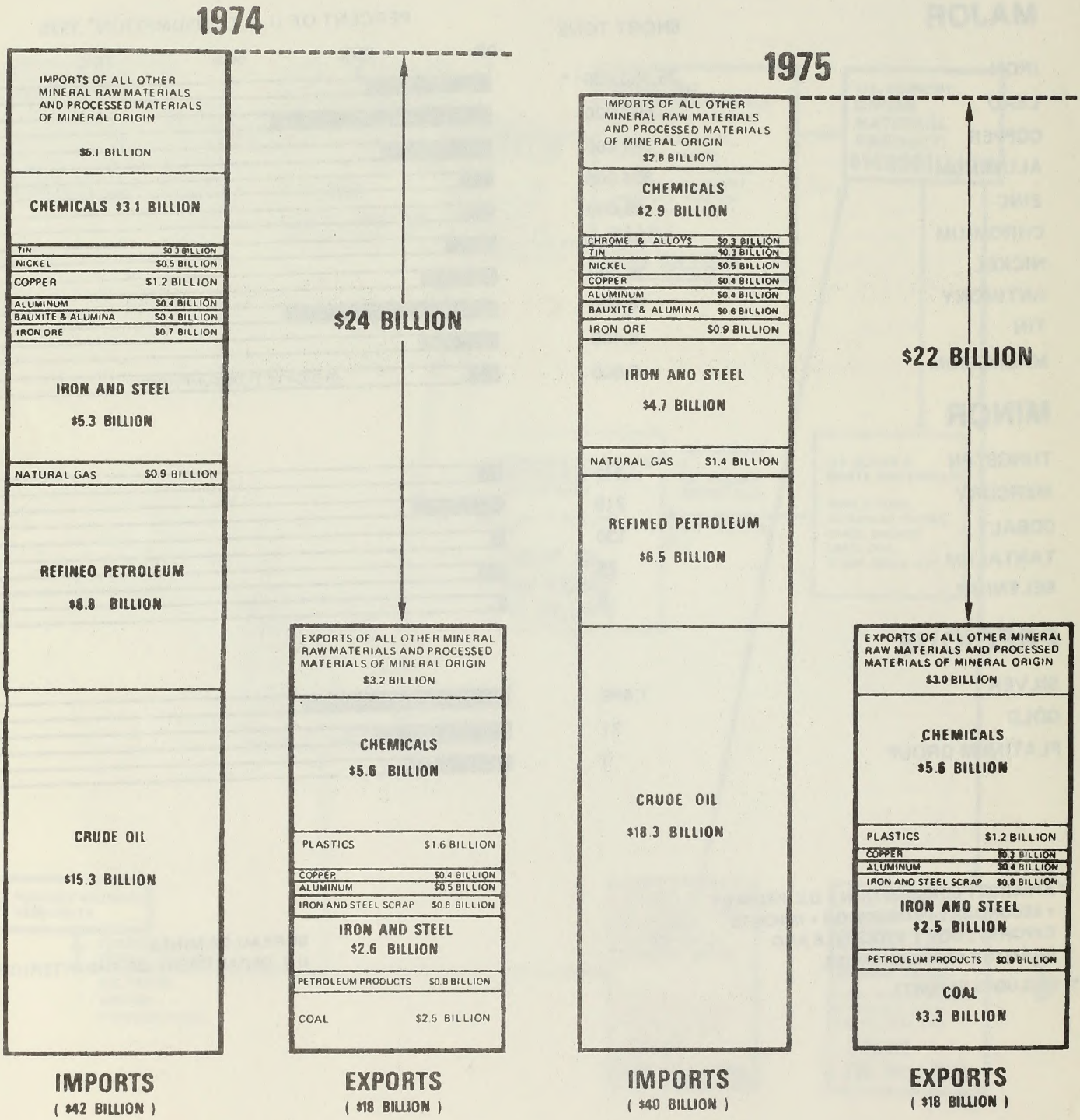

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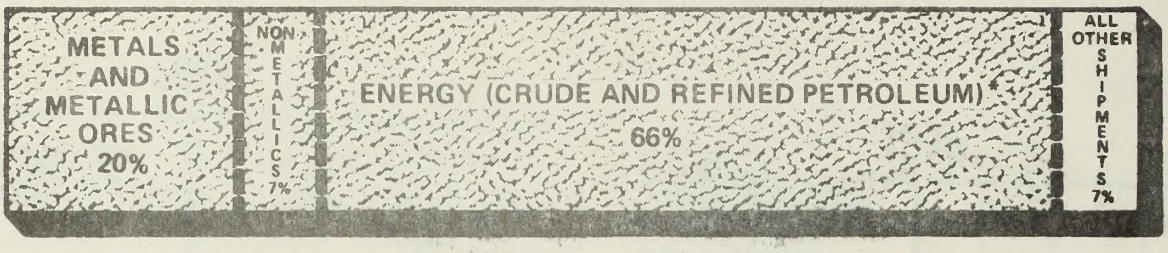
Figure 9

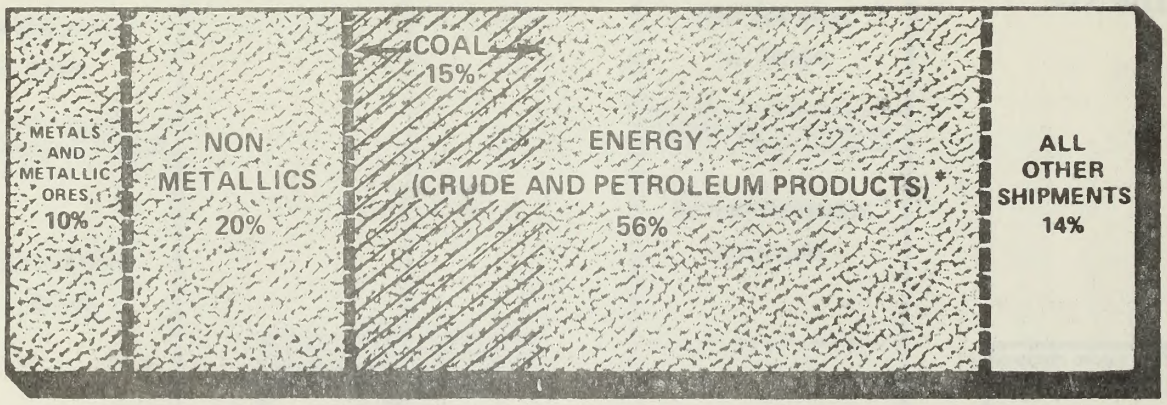
MINERALS ARE MAJOR TRANSPORTATION USERS

U. S. WATERBORNE IMPORTS 1974 = 497 MILLION TONS

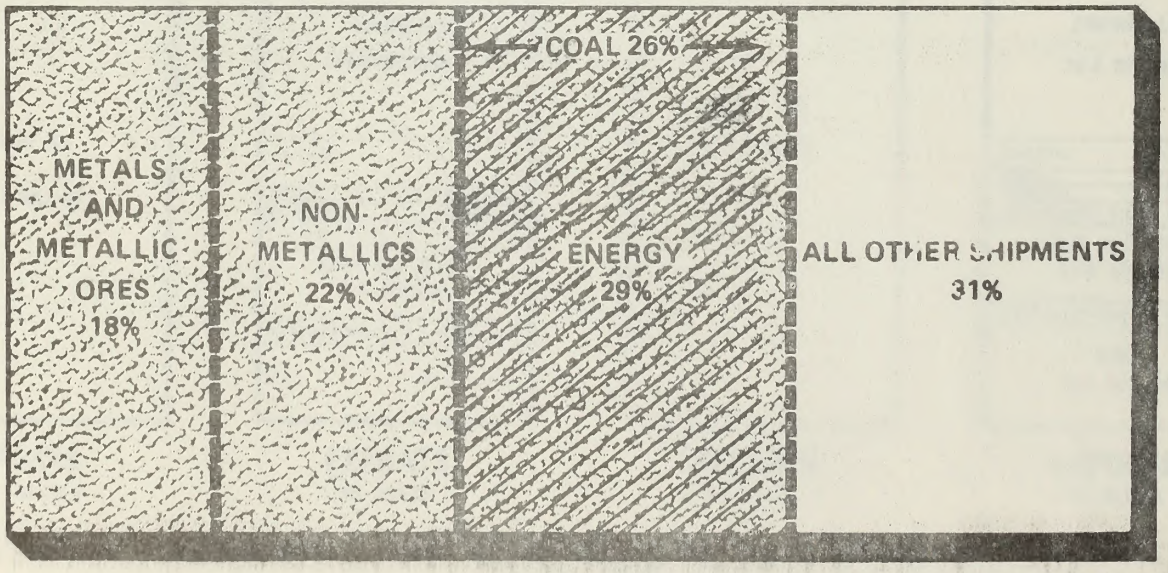


U. S. WATERBORNE EXPORTS 1974 = 267 MILLION TONS

DOMESTIC WATERBORNE COMMERCE 1974 = 983 MILLION TONS



DOMESTIC RAIL TRAFFIC 1974 = 1531 MILLION TONS



*PRINICPAL COMMODITIES SHIPPED

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